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Wightman,

Arthur Clarence

1899

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On the
Ventricular Epithelium of the Frog's Brain.
By
Arthur Clarence Wright.

— 9 —

Respectfully submitted to the President and
Faculty of the Johns Hopkins University for
the purpose of obtaining the degree of
Doctor of Philosophy
of

Arthur Clarence Woodward
May 1st, 1889.

On the Ventricular Epithelium of the Dog's Brain.

In the July number of the Johns Hopkins Univer-
sity Circulars for 1888, there appeared a
short abstract - the Ventricular Epithelium of
the Dog's Brain. The following paper is the
detailed account of ^{the research described in} that abstract. Before proceed-
ing to discuss the methods and results of the work,
a brief account of the results reached by previous
investigators is desirable.

In 1844, Adolphe Annauer ^{*} who was the
first to study the frog's brain with a microscope,
stated that all the ventricles of the brain are lined
by cubical, striated epithelial cells, from whose deeper ends
long fibres extend toward the periphery. He considered
the cells not as epithelial, but as true ventricu-
lar cells.

Albino Blatin in 1851 described the
wall of the ventricles as being lined with cubical

* This quotation refers to the abstract at the end of the paper.

Epithelium

Epithelium, 0.002, 24, the tissue was
also in lined with flattened epithelial cells.

0.002 Epithelium - large cells - characteristic
like central nervous system of the frog, as per
reference to the epithelium, - in the central part
of the dorsal wall the cells are cylindrical spherical
or spindle shaped. It is uncertain whether these
cells are elongated or not - from the tips of the cells,
the tissue being turned towards the cavity of the
ventricle, long processes run out into the grey sub-
stance. The thickness of the epithelial layer is
0.036 μ - in isolated cells is in length - from
0.024 μ - 0.036 μ , in breadth 0.005 μ - 0.008 μ .
The nuclei have lengths from 0.006 μ - 0.012 μ .
Though the nuclei possess no nucleoli but
are filled with fine granules. A layer of
serous membrane lining the bases of the epithelial
cells. In the serous membrane the cells are
much like those of the ventral wall - the

variation, with *Deuterodon*, mostly in size seldom
 a form. It should be noted, when the wings of
 the hind and front ventricles the long petioled
 cell are into that cell. From the ^{inner ends} of these
 cells processes can be traced far into the frame.
 In numerous and a quarter is a dotted scene.
 The only small blackness is seen bordering the
 edge of the cells. From the same point clusters
 of fine hairs. Clearly prominent can be seen by
 simple eye segment is a little chalk. Numerous
 used various "memor to mention" the petioled
 surface in order to observe the movements of the
 cells. The nature of the medulla and the rest of the
 frame are some by cells similar & there are
 needed. The processes & branching from these cells
 give a striated appearance to the frame.

Schönle & Huber have the power to see
 spherical cells in the central canal of the spinal
 cord - the so-called "dendrites" in optical
 relations. (Of course, he is wrong.)

In 1889 Richard Suda published his work on the nervous system of Leptothorax. In regard to structure of the Leptothorax - The central canal of the oblong cord is lined by epithelial cells which are columnar shaped the bases being turned towards the cavity. The cells measure at their bases a breadth .014 μ - in length about .04 μ . The nuclei are large rounded oblong and .002 μ in length from the cells bordering the anterior and posterior ventral and dorsal sides of the canal four fine processes run off, which processes become attached to similar processes of the perivascular cells bordering the lateral regions of the canal. These processes shorter and finer. The brain cavity, like the central canal, is lined by a single layer of epithelial cells. A long process runs out from the top of each cell. At certain regions of the brain the epithelium changes in character. One or two water pig covers the ventricle - is in the 1st nucleus

Commons Polychaeta Amphipoda, the ventral
surface under the metellum and so forth — the
epithelium lining the surface of the metellum
the metellum itself becomes flattened.

In another publication of 1875, Stieda describes
the metellum of the polychaete. In the spinal
part of the animal, the cells are not regularly
arranged around the metellum and metellum but in
groups. The cells are of two kinds: the ones
spindle shaped with a long neck, the other one
cubical. The nuclei of these two kinds of cells lying
at different levels, those of the spindle cells lying
farther from the canal than the appearance of a
double row of cells whereas there is only a single
layer. The cells vary so in size that no satisfactory
measurements can be given. The nuclei measure
0.12 μ - 0.18 μ . The processes from these cells
connect with the metellum. In the fourth
metellum the cells are regularly arranged in
rows of spindle shaped cells their bases towards

It is a triangle. The cell is very large. Area = .024 sq. mm. in breadth in short. The relation of cone and spindle cells to the dendrites in the central canal. The long necks in the spindle cells are inserted between the cone cells. The apical dendrites of the other dendrites resemble that of the fourth ventricle.

Strada is describing the central nervous system of the *Hydra* (see page) - in the head he could not establish the connection between epithelial processes and the dendrites as located in the frog. The cells are smaller, ill-defined, and possess nuclei of from .005-0.01 mm in size. The structure of the cell and the processes of cells could not be made out. The mainly spike cells among the dendrites are cylindrical cone and spindle cells are also found. Cells vary in the different portions of the brain. The grades of transition forms can be seen. All the cells are situated. The dorsal elements of the brain are all constructed

side. The inner E. a. combination of peduncle
and epithelial cells. The per. becomes much folded
and the folds are lined with cells which are
continuous with those of the ventricle & the brain
the blood vessels run in these folds the cells
are not distinct.

Miegjewsky published his paper in 1872 (?) .

He says that the epithelial cells of the ventricle and
of the central canal form a continuous layer. They ^{are}
columnar or flattened in shape, with a distinct
The cells of the ventricular epithelium send out long
processes. In the central canal the cells on the
ventral side are much larger and possess much
longer processes than those on the dorsal side.
There is however no sharp transition line between
them. The same is true of the ventricular epithelium
of the brain. The cells on the ventral surface are
much larger and possess longer processes than
those on the dorsal.

Karabanowitsch in 1873, D. claims that all

the cells lining the central canal are dilated and that the long processes connecting with the cord, form themselves in the connective tissue.

Hoffmann, in 1878, examined Suda and Hisser in their descriptions of the Epithelium of Spinal Cord and Brain (11).

Mason (12) also says that in the frog the epithelium of the ventricles of the brain and of the central canal of the cord consists of several related cells. From these cells ^{processes} [^]run out & become continuous with the substantia reticularis.

It is maintained by Seerke in 1883 (13) and again in 1885 (14) that the epithelial cells of the ventricles and of the central canal are connected by their processes with processes from glia cells.

Christensen says, and that the findings of modern research show that the epithelium of the ventricles of the brain and of the central canal of the cord is of a nervous nature. Christensen

processes from the epithelial
 cells of the spinal cord by Botcher's technique
 can be followed some into the posterior root
 some into the anterior commissure. All the
 cells are ^{and possess} ~~large~~ ^{large} nuclei
 having nucleoli. It is probable that the epi-
 thelium lining the medulla is most intimately
 related to the nervous elements the cells and
 fibres. All the ganglion cells of the central
 organ are derived from the epithelial cells -
 though the transition from one form to the other
 is not clear. In Amoco's according to
Horns, large ganglion cells arise within the
 ventricular epithelium by the growth
 of certain cells, these cells then work into
 the brain substance to become ganglion cells.
Grund found that the processes from the
 epithelial cells and nerve fibres stained
 exactly ^{alike} ~~alike~~ with gold.

Dissection of the Frog - In order to dissect the
brain and spinal cord of the frog from the cranium
and vertebral column, the following method
was adopted.

The frog
used was the *Rana catesbeiana*, the common bull
frog. The animal was killed with ether or chloro
form. After removing the skin from the back and
from the top of the head, ~~the dorsal muscles of the back were~~
~~stripped off up to the base of the skull.~~ With a
pair of scissors the vertebral column was severed
just anterior to the pelvic girdle. Holding the ^{process} ~~specimen~~ ^{ous}
up by the not-box with the forceps, it is easy to intro-
duce a pair of scissors into the neural canal and
to successively strip the neural arches ~~processes~~ ^{processes} off all the
vertebra, working from posterior to anterior, lifting
up at the same time the separated portions. In this
way the whole of the dorsal half of the vertebral column
and of the cranium can be taken off, leaving the brain
and spinal cord absolutely unimpaired. After

Cutting

in view of the cerebro spinal cord the
whole central nervous system can be easily injured and
the brain and spinal cord are obtained wire transferred
to one of the usual hardening agents in 20% or
40% Potassium bichromate, Potassium subbromate
Nitric acid or Picric acid
for the purpose of staining, Gramatoxylin,
Laurie's method, the method of Gramatoxylin, Ingram
Lupronin, (brown), (bright), Gramatoxylin method,
Golgi's silver nitrate method and Gold chloride
were used. The method which perhaps gave more
satisfaction than any other is to place the brain
and spinal cord in 5% nitric acid for 2 hours
wash out well in running water ^{for} 1/2 hour, transfer
to 3% alcohol ^{for} 3 hours, then to 5% ^{for} 2 hours, 70% for
1 hour; 80% - 90% indefinitely; two days is
enough. After staining sufficiently the brain
and spinal cord wire are washed in water and
then worked for 1/2 hour at least with a 2%
solution in Potassium bichromate and then in

washed

was quickly ⁱⁿ distilled water and transferred to a solution of Scherer's anisotrophen. In this solution of anisotrophen the specimen was kept for 2-3 days heating the solution each day for 1 hour up to 38°C. It was then well washed in water, dehydrated, embedded, ^{sections cut} ~~cut~~ with the microtome and mounted in the usual manner. This method, a combination of those recommended by C. J. Neust and R. B. De, yields excellent stains of the epithelial lining of the brain. ~~The~~ stained sections the surplus color can easily be removed with acid alcohol.

For the preparation of fixed specimens Logel's method II was followed with certain changes. The brain and spinal cord was removed from the cranium and vertebral column by the above given method. The ventricles and vertebral canal were laid open so as to give free access to the meninges and then the whole was placed in a 4% solution of formalin and left for 10-24 hours - then, after being thoroughly washed with distilled water.

placed under a microscope in a little water for one week. The specimen was finally transferred to a mixture of one half glycerine one half water for a day - then to pure glycerine.

Small portions of the brain were placed under a drop of glycerine under a cover glass supported by a bit of paper to prevent undue pressure.

By tapping or by giving a gentle sucking action to the cover glass by alternately pressing and relieving, the cells can readily be expanded.

Distribution of the Epithelium. The epithelial layer of the frog's brain and spinal cord forms a continuous lining to all the cavities of the central nervous system. Its configuration is along a layer thin. Though forming a continuous lining, yet the character and size of the cells vary considerably. In the lateral ventricles (Plate XXII, Figs. 1, 2, 3), at the middle region of the right and left surface of the cavity the cells are regular

in shape and size and closely in a single layer;
 at the dorsal and ventral angles of the cavity
 these cells become slightly larger, more rounded, less
 regularly arranged from the tip of each of the
 basal cell a tail like process can be seen running
 into the brown substance where it becomes lost.
 In the transverse section, at the dorsal position
 (a roof of the ventricle) and ventral portion of the
 cavity, the cells are typical epithelial cells, Plate XXII
2, figs 4, 5, 6. In the middle region,
 however, these cells are larger, more rounded,
 apparently two layers deep, and, from their tips,
 much stronger processes penetrate the brown
 substance. Those cells lining the internal surface
 of the periventricular forming the roof of the ventricle
 are, on the contrary, small, cuboidal, and appear
 entirely featureless. The columnar and conical cells
 of the lateral wall of the ventricle pass gradually
 into these cuboidal cells, Plate XXII
2, fig 4.)
 Stieda 1912 and more recently (1913) have seen that in

this change is in contrast from it. In the
 region of the gill cover (Fig. 7) the epithelium
 has different appearance at different parts, —
 those lining the cavity rather soft & lab. shows small,
 regular and not particularly noticeable; from
 there small cell processes run into the brain sub-
 stance; — those cells lining the duct of
Syllivius are more than twice as large and much
 more rounded especially at the ventral edge of
 the cavity and have extremely long and noticeable
 processes. (Figs. 7 and 8). In the fourth ven-
-tricle (~~Pluteus~~ Figs 9, 10, 11) the cell lining the
 floor are comparatively large and possess long
 and strong processes — the cells of the roof, the
 ventricle is smaller and their processes are
 so conspicuous. The apparently is the general
 rule — the epithelial cells on the ventral surface
 of the ventricle are larger than those on the dorsal
 — see Margenau's (2) figure above. It is certainly
 true for the frog (Figs 4, 7, 8, 9, 10, 11).

The relation of the Epithelial cells to the Brain cells - The most necessary examination of a series of sections from the brain by the light will reveal the fact that there is a definite relation between brain cells and the epithelial lining. Passing from the outermost backward and going on we come at last with a section taken from the region of the central hemisphere Fig. 1. It will be seen that the cells of the brain are arranged not promiscuously but in groups and layers concentric to the epithelium, the processes from these cells give the brain a striated appearance. More posteriorly in the striated cortex the concentric arrangement is still more striking (Fig. 4). Here not only are the brain cells arranged around the epithelium but there is a lateral portion of the epithelial lining which seems to be the cerebral region. In Fig. 4 the spot is shown on the lateral walls where the epithelium appears folded - Fig. 5 ~~shows~~ is a representation of the left surface of the brain

the cells here are larger more numerous and especially in several layers. Compare this with Fig 6 taken from the left side near the ^{central} tip, yes on along the processes are longer larger and more numerous. Here and still more posteriorly, in the third ventricle ~~the same~~ ^{still} arrangement is seen - a central region in the epithelium about which the brain cells are concentrically grouped along the region, also, the cells are larger seemingly in several layers, and have longer processes. ~~compare Fig. 2 & 3.~~

In the region of the optic lobes (Fig 7) the relation of brain cells to epithelial cells is the same. The concentric grouping is still there. Close to the epithelial lining of the optic lobes mainly is a layer of brain cells, just beyond a layer made up of fibres from cells and processes from the epithelium, next a layer of brain cells not so closely packed as the first layer; then another fibrous layer then another cell layer another fibrous, and so on. The

layer becomes very thin and thin layers until the
 sharp distinction between one layer and fibrous
 is lost and the cells and fibres become promiscu-
 -ously mixed. In the conduct of Syllus
 the epithelial cells are of the same size and shape
 as those at the ventral region of the thor. (note
Figs 7 and 8 Plate 6, fig 2). The processes from these
 cells can easily be traced into the brain substance
 for a distance three or four times longer than the
 cells. The ventral angle of the conduct of Syllus
 is most interesting (Fig 8 Plate 5). The epithelial
 cells can be most distinctly made out and their
 processes followed for an astonishing distance.
 Beneath the epithelial layer lie little packets
 or groups of cells. The clusters contain varying num-
 bers of cells. Each cell of the cluster sends out two
 processes - one goes to an epithelial cell and becomes
 united with it - the other penetrates the brain
 substance and becomes lost. Apparently these
 clusters are groups of cells which descend from the

the lining epithelial layer - the size and shape
of ~~the~~ ^{the} nucleus of both classes of cells the
superior rounded staining segment, the direct
connections with one another i.e. adjacent cell to
adjacent cell indicate that these cells of the pith
are closely related to brain cells - are probably
intermediate between brain cells and epithelial
cells - that being derived from the epithelial layer,
they probably represent the half way stage between
epithelial cell and brain cell. The hair processes
of the epithelial cells lining the ventricles of the
large brain, and, therefore, the connections or
the remnant of the connections existing between
epithelial and brain cells.* In the fourth ventricle
Figs 9, 10, 11) the same general arrangement is found
the floor of the ventricle is lined with large epithelial
cells each sending out into the brain substance a
very strong process, fig. 21. In Fig. 9 ~~figure 9~~ the con-
-tillum is outlined, and [^] ~~the~~ ^{the} cells do not appear
on such a section to be arranged in any regular

* See Observations, 9th edition, page 2

epithelium. Fig 11 will show the size, shape and arrangement of the cells lining the epithelium. The cells are small, more regularly set and do not present such pronounced features.

Structure and Connections of the Epithelial

cell. Having now the examination of stained specimens and passing to a study of carefully-fixed preparations, it will be noticed as Rhoda has already shown for the epithelium from rabbit (p. 10) that there is a series of cells which vary much in size and shape. However, there is a form of gradation between these two widely different forms. The cells of the epithelium may be conveniently described as consisting of two typical kinds - a columnar and a squamous like form. Between these two kinds there is an intermediate shape. Each presents many variations. On a surface near a small bit of the epithelium show a closely packed sheet of cells - the columnar-shaped cells presenting a diagonal area under the microscope.

and their contents being recognized by oil-soluble spots on dark short lines scattered within the cell. The columnar cells (Figs. 17, 18, and 22.
~~(Figs. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100)~~) consist of a short more or less regular body, from the basal end of each cell they project into the intercellular cavity a closely but distinct cilium. Each cilium ^{leaves} at its base where it joins the cell an enlargement. The row of enlargements is the cause of the so called basal stain when seen under low power of the microscope. The protoplasm of the cell can be followed directly into the cilium. The other end of the cell tapers more or less suddenly into a long comparatively distinct protoplasmic process.

The other class of cells the apical (Figs. 12,
15, 18, 22, 23, & 25.
~~(Figs. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100)~~) largely consist of an oval or oblong body from the apical portion the body tapers into two processes one going to the ventricle where it expands again at the surface into a small enlargement. The

little heat is borne the ^{of} ~~clash~~ [^] ~~cell~~ and work
to real mulling - the other process ^{runs}
from the body with cell ^{and} [^] ~~process~~ the long tail which
penetrates far into the ~~body~~.

Between these two classes of cells (18) - a range
of gradation. Cells are frequently found
possessed of an extremely long and thin ventricular
process with no expanded tip (Figs 18, 25
Plate 1), others are seen whose ventricular
processes are nearly at all contracted (Figs 15, 20, 22,
Plate 2); ^{then} [^] ~~then~~ ~~are found cells~~
of a true cone shape with no ventricular process
whatsoever (Figs 18, 19, 21, 23, 27
Plate 1); finally we reach those to the other extreme
class the cells - (Figs 17, 18, 22
Plate 2) In Fig 28 - shown an
extreme spindle form - the extreme class of
cells can easily be seen.

An interesting modification of the spindle cells
will be shown by Figs 13 and 14 - These

central body, also sends out two processes, the one running into the larger substance, the other extending towards the ventricle. The latter is to course expand so as to become spoon shaped fitting nicely in between the cone shaped or tubular ones. In the choroid plexus, viz., the spoon shaped process is above the row of nuclei. As Stueda 7, showed that in the epithelium of the spinal cord of the axolotl the cells were in a single row, the upper and lower double row of cells being due to an nuclei being at different levels, so, from the appearance of several layers of cells as seen in Figs. 4, 5, 6, 7, 8, 9 is Plate 1, 2, 3, 4, 5, 6 due to the different relative positions of the nuclei belonging to the same row of cells described above - see Figs. 15, 18, and 23. Plate 1, 2, 3, 4, 5, 6 The epithelium of the ventricle of the frog brain is composed of a single layer of cells. As to the size of the cells, Roseman 9, 10, measured an apparently typical length, 124 μ . 93 μ ; breadth . 60 μ . 68 μ - length of the nucleus, 50 μ .

C12a

The cell processes mentioned are frequently seen in abundance from the 4 to 6 each side of the brown substance deserve special attention. It will be seen by reference to the historical picture of the paper that the majority of investigators assume that these cell processes are connected with the nucleus. The results of carefully stained preparations do not support such a conclusion. No cell has been isolated which did not possess a cell process - except perhaps those cells mentioned above, which form the internal lining to the roof of the 3rd and 4th ventricles. The processes vary much in size and length. They are small and delicate in the external lateral horns, strong, and long in the third ventricle, small and delicate in the cavity of the 4th ventricle, strong and well developed in the aqueduct of Sylvius and the fourth ventricle. In the Figure above these processes are frequently seen.

(Figs. 15, 18, 19, 24, 26.
Successfully made preparations ^{show-} 1 in branched. 2 One at least with branches and in a brain cell. (Figs 16, 19, 23, 26 and 27).
Although the real processes

are branched, yet a process in connection with two or more brain cells has not been seen. Starting from the epithelial cells the tail processes penetrate the brain substance, branch, and by at least one branch unite with a brain cell — the epithelial cell is directly connected with the brain cells.

The same is true for all portions of the intracranial cavity - epithelial and brain cells are connected as well be indicated by the following figures.

The Brain and spinal cord of a frog were ^{carefully} removed, as in the method described above and placed in a glass trough under normal salt solution. The cerebral hemispheres were cut open by a longitudinal slit through the dorsal angles of each hemisphere.

as in Fig. 2. The *ventriculus* is the lateral
 ventricle. The same was done for the ventriculus
 after the other tube. The equivalent of *Syllis* the first
 ventricle and the central canal of the abdominal
 cavity is continuous with a passage from the
 lateral ventricle down to the central canal near
 the *operculum*. With the microscope the cilia
 could now be seen in other motions. If, now,
 with a pipette a drop of water containing finely
 ground cambric be placed in the cavity of any
 of the ventricles, a most interesting sight will
 be obtained. Some of the cambric particles sitting
 in the water are caught on the cilia, and afford
 an excellent means of watching the movements of
 little particles of cambric as they are carried
 to and fro. At a temperature of 15°C . the
 following measurements were made. No. 1. With
 a comparatively large cambric particle in view
 the third ventricle beat 2.5 times per minute.
 No. 2. In the same field of the microscope with

close to No 1 a columnar mass in a series of columns
 about $\frac{1}{2}$ in. long, that of No 1 beat 220 pr. min. &
No 3 the fourth ventricle a columnar mass 108 pr. min.
 columnar particle larger than that of No 2, No 4
 fourth ventricle columnar mass 104 pr. min. columnar
 smaller than No. 2; No 5 fourth ventricle, 138
 pr. min. columnar same size as that of No 2.

The cilia of the cells of the columnar mass, also
 beat at the rate of from 100 to 200 strokes pr. min.
 No such thing as a wave of esthary motion could
 be observed passing along the water film but although
 the microscopic field cilia could be seen beating
 independently some slowly some quickly frequently
 side by side at different rates. Each beat con-
 sisted of a quick vigorous stroke and a com-
 paratively slow recovery. By carefully watching it
 was seen that the viscous strokes were directed anteriorly
 posteriorly - consequently on watching the floating
 columnar particle a current of motion was slowly
 drawn from ^{the} fore down backwards. The

phenomena were observed in all the sections of the brain as well as in the spinal cord, and

In one case was shown evidence of the presence of denting membranes, either internal or external, to the epithelial lining of the ventricles (Fig. 28 ~~Fig.~~). The cells sometimes show a tendency to adhere by their bases, the ventricular ends, but this may be due to the presence of an adhesive substance, or to the interlocking of the hardened cells - certainly, no separate membrane was found nor was there any indication ^{in the cells} of a tendency to adhere by their other ends - this is false. *

Conclusion 1. The epithelial layer of the frog brain and spinal cord forms a continuous lining to the central nervous system. It is very thin - a single layer thick.

2. The substance of the brain forms a central zone of cells about which ^{the brain cells} are concentrically arranged.

* The brain and spinal cord of the tadpole of *Xenopus* shows a frog was ^{also} examined in stages the same method. The results were a great deal the same as above.

3. The cells of the epithelium and of the lining are connected by processes which extend from the tips of the former.
4. The endothelium consists of cells of several varieties: the columnar, the spindle, and the median forms. All are isolated and their cilia beat with independent action.

Before closing I would like to express my thanks to Professor Martin for valuable suggestions and also to Dr. Brooks to Dr. Howell and to Dr. Donaldson for assistance rendered during the progress of this work.

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done on the central nervous system, but it
contains nearly the most important papers which
relate to the structure of the prothalamium and the
prothalamium.

Explanation of Plate XXII.

Fig. 1 Cross section. Corbale. Showing
oblique calcification tract - Nitric acid and
Hornstouphen. Lens Camera. Obj. A.

Fig. 2 Upper or dorsal angle of the ventricle
from Fig. 1. Lens B.

Fig. 3 Lower angle of ventricle - Lens B.

Fig. 4 Section across anterior portion of the third
ventricle. Fig. 4 General view. Lens Camera.
Obj. A. Treatment same as Fig. 1.

Fig. 5 Middle portion of left ventricle - cut
from Fig. 4. Lens Camera. D.

Fig. 6 Lower part of same side - Lens Camera D.

Fig. 7 - Corro. posterior part of the third ventricle
Lens Camera. Obj. A. Treatment same as above.

Fig. 8 and 9 - Middle and ventral portions
of the third ventricle.

Fig. 10 - Section from ^{the} optic lobes - showing optic
lobe cavity and the adjacent region of Epithelium.

17. 18. 19.

10. 11. 12.

13. 14. 15.

16. 17. 18.

Fig. 8.

Central angle of contact of Silene from

Fig. 7

~~Pf. 1-1~~

799

Fig 9. Section across the crystalline and
granitic intrusions - Victoria road - Hematite vein

see can. of. A The details of the structure of the cerebellum, ^{has not been drawn}

Fig 10 - *Sp. tuberosus* at 100 to 150 ft. angle of the fourth
ventricle - Same place as Fig 9

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Epithelium of the villar wall of 2, 9.

Transcript Method

De la

Fig. 19

Fig. 19 - Isolated protoplasmic cells from
lateral ventricle - ~~diffusion of the same fluid~~
Shows isolated epithelial cell, branched process, and
unions with brown cell. Dogiel's method.

15 and 18

15 and 18, groups of epithelial cells and plasma
12, 20, ~~21~~, 21, and 25 isolated. *cc.* Third Ventricle.

fig 19, from lateral

Shows elongated epithelial cells long processes,
and their union with brain cells

Plate 8 Fig 28 Piece of the wall of the third ventricle
shows the different layers of cells

^{13 and 14.}
Figs. 23. Cells from third ventricle, ~~Fig 23~~

~~cell with spoon shaped ventricular processes.~~
Fig 24. Isolated cell with branched process. Lateral Ventricle.

~~cell with long process~~
^{12, 17, and 22}
Figs. 21, 22, 23. Cells like columnar and
spindle shaped. Third ventricle and adjacent
of thalamus

Fig 23 Cells from 3rd ventricle - spindle cells
and a cone cell are shown the process
from the cone ^{cell} ~~unites~~ with a multipolar brain
cell. Fig 4. D.

Fig 27. Third ventricle. isolated cell sends
out the process which joins a brain cell
Fig 27. C.

Fig 16. Optic Lobocavity - Shows connection of epithelium cell
to brain cell.

Fig. 26. Third ventricle - Isolated cell with branched
process joining a brain cell.

FOLD OUT

Vita

Arthur Clarence Wright was born in Columbus
S. C. Feb 27th, 1839. He was prepared for
College at a private school in Charleston S. C.
At Wofford College, Spartanburg S. C. his
course embraced the following: - languages,
Greek, Latin; ⁱⁿ mathematics; - geometry,
trigonometry, surveying, calculus; - ^{in the} sciences -
geology, chemistry, physics; in the department of English
literature, - ethics, logic and belles lettres. In June
1879 he graduated with the degree of B. C.
After graduation, he taught for five years as
principal of the South Lyons Academy St.
Matthews S. C. He was, then, in 1882 elected
principal of the Summerville High School,
Summerville S. C. where he taught for one
and a half years. Upon his resignation
he entered, in the fall of 1884, ^{the Biological and chemical laboratories of} the John
Hopkins University to ~~study in the~~
Biological and Chemical Laboratories.